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Energy loss caused by shielding effect of steel cage outside source tube

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Abstract The energy loss, produced by shielding effect of steel cage outside the source tube, is quite considerable. With PENELOPE software package, MC results have been obtained based on the simulation of different source conformations. The result illustrates that the naked source tubes can improve the utilization ratio of the cobalt facilities. It demonstrates the applied value of the naked source tube in engineering.

Key words Monte Carlo simulation, PENELOPE software package, Shielding effect, Steel cage, Cobalt source tube
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1 Introduction

With the development of applications of radiation processing, China has become a leader in radiation technology[1-6]. There are nearly a hundred of the cobalt radiation facilities all over the country up to now. The design, installation, debugging and running of the cobalt facilities have become more and more mature. But how to improve the utilization ratio of the cobalt facilities is still a question. According to the real situation of the source tubes, there should be a steel cage (0.1cm in thickness) covering the source tube. So, when running radiation processing, gamma ray radiated from the source tube doesn't directly irradiate products. Firstly, it penetrates the steel cylinder of the source tube. And then it penetrates a steel cage. Finally, it irradiates products. It is no doubt that gamma ray will lose some energy during the above-mentioned penetrations. In view of microcosmic physical processes, relative probabilities of all kinds of microcosmic physical processes result directly in the energy loss of gamma ray. It is well known that all the interaction processes between gamma ray and matter can be described by Monte Carlo simulation. The main interaction processes in the cobalt facility are coherent (Rayleigh) scattering, incoherent (Compton) scattering, photoelectric effect and the electron-positron pair production. Which kind of interaction process dominants the radiation processing depends on the material and the geometry of the absorber. It also depends on the energy of gamma ray. Apparently, these interaction processes bring about the energy loss of gamma ray during the penetrations [7].

In this experiment, we made use of PENELOPE software package to simulate C-188 source tube which was produced in Canada.

2 Simulation and analysis

In our calculation, there are some practical situations, which should be taken into consideration:

1) the source configurations were classified: a) point source; b) line source; c) plane source; and d) cylinder source (see Fig. 1);

2) "observation" means the detected area where we get MC data (see Fig. 1);

3) steel cylinder: 0.1 cm in thickness;

4) steel cage: 0.1 cm in thickness;

5) energy of gamma ray: 1.17MeV and 1.33MeV, 50% separately.

There is little influence of air on the shielding effect, so it is omitted in the calculation. Then the

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thickness of steel in 0.2 cm is obtained.

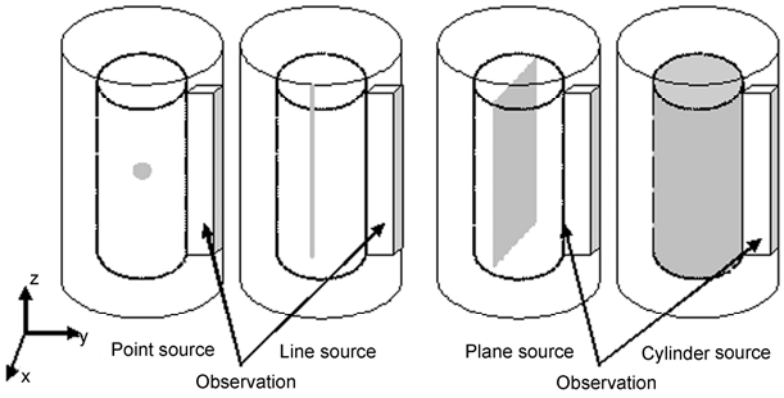

Fig.1 Various geometries of the source tube.

The result shows that the statistical error is only about 1%, so it is quite reliable. The Monte Carlo simulation gave the deposited energy distribution (see Fig. 2) and the depth dose function (see Fig. 3).

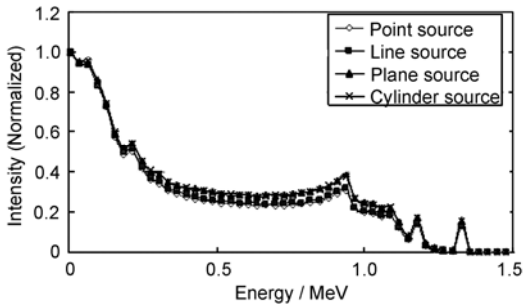

Fig.2 Deposited energy distribution in 0.2 cm steel.

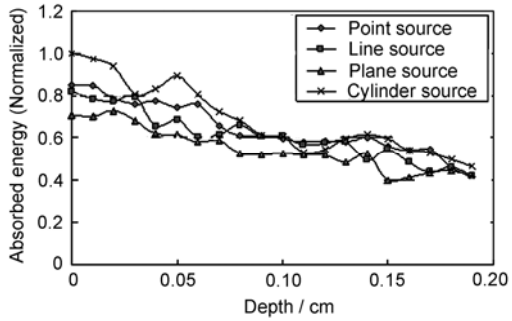

Fig.3 Depth dose function in 0.2 cm steel.

The energy loss is chiefly caused by incoherent (Compton) scattering at low energy, as shown in Fig. 2. For the point source, line source, plane source and cylinder source, the energy loss in 0.2 cm steel is 6.0%, 5.9%, 6.7% and 6.7% respectively. And the behavior of different source geometries is very similar. The result shows that the energy loss originating from the shield effect of the steel cylinder and the steel cage is quite considerable.

3 Summary

With PENELOPE software package, MC simulation results have been obtained based on different source conformations. The shielding effect produced by the steel cylinder and the steel cage has been discussed.

The result shows that the energy loss chiefly caused by Compton scattering cannot be ignored. This considerable energy loss in the steel cylinder illustrates the applied value of naked source tubes in engineering and gives a way to improve the utilization ratio of cobalt facilities.

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